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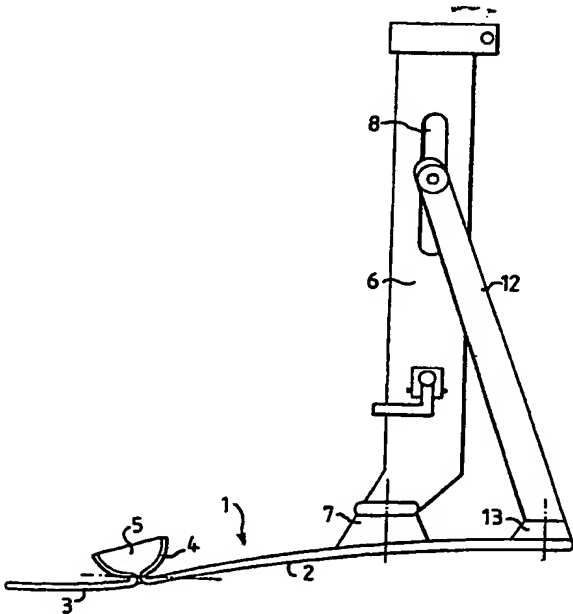
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : A61F 2/66	A1	(11) International Publication Number: WO 91/15171 (43) International Publication Date: 17 October 1991 (17.10.91)
(21) International Application Number: PCT/SE91/00239 (22) International Filing Date: 28 March 1991 (28.03.91) (30) Priority data: 9001184-2 2 April 1990 (02.04.90) SE (71)(72) Applicant and Inventor: GRAMNÄS, Finn [SE/SE]; Brantalid 18, S-511 56 Kinna (SE). (74) Agent: TJERNBERG, Nils-Ivar; Box 47 300, S-100 74 Stockholm (SE). (81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI pa- tent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OA- PI patent), GB, GB (European patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.		Published <i>With international search report.</i> <i>In English translation (filed in Swedish).</i>
(54) Title: ARTIFICIAL FOOT (57) Abstract <p>An artificial foot which includes a foot blade (1) and a hollow cylindrical body (6) which extends at an angle to the foot blade and which is connected thereto in a manner to permit relative movement therebetween. The foot also includes a two-part brace (12) which is displaceable and adjustably mounted in an upper end of the cylindrical body (6) and is attached to the foot blade (1) at a lower end of the body in a manner such as to permit relative movement between the foot blade (1) and the brace (12). Displaceability and adjustability of the brace (12), and therewith angular adjustment of the foot, are achieved by virtue of the fact that the upper part of the brace (12) acts on the shaft (11) in a ball screw whose ball nut (9) is rotatable, and when necessary lockable, attached to the inner surface of the cylindrical body (6).</p> 		

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ARTIFICIAL FOOT

5 The present invention relates to an orthopedic foot according to the preamble of Claim 1.

10 It is well known that it is troublesome for people wearing a prosthetic foot to walk downhill. In those cases where the person wearing a foot prosthesis is not able to adjust the foot angle, it is only the heel which has contact with the road surface or like surface when walking down a steep slope. Over a given number of degrees of foot angle, it is difficult to hold back, or brace the body, so that the knee will not collapse (due to the absence of important muscle groups). Con-
15 sequently, the wearer of the prosthesis will often choose to walk sideways down a slope.

20 Furthermore, the wearer of a prosthetic foot which lacks the possibility of adjustment in the height direction finds it problematic to change to a shoe of different heel height, and of quickly choosing to walk without shoes. Individual adjustment of the foot in a vertical or height direction also alleviates problems
25 associated with back pains and worn hips.

An adjustable prosthetic foot is known, for instance, from the U.S. Patent Specification No. 2,749,557, although this prosthetic foot can only be adjusted in
30 three different angular positions.

The Swedish Published Specification No. 456 134 teaches a prosthetic foot with which the angular positions thereof can be adjusted by means of a screw provided in
35 the heel of the foot. In order to change the angular

position of the foot, it is necessary for the wearer of the prosthesis to turn the screw an appropriate number of turns, which requires a certain amount of effort on the part of the wearer. The angle-changing principle taught by this publication has the serious drawback that the length of the leg remains changed, which means that in some positions, the wearer may limp on the right or the left leg.

One object of the present invention is to solve the aforesaid problems and to provide an adjustable resilient foot prosthesis which can be adjusted to an innumerable number of angular positions quickly and smoothly. Another object of the invention is to provide a foot prosthesis which is light in weight and which will thrust the foot forwards when a walking step is completed and which will also eliminate those drawbacks associated with earlier known techniques. The solution to these problems is set forth in the characterizing clause of Claim 1.

Figure 1 illustrates a preferred embodiment of the invention.

Figure 2 is a sectional view through a hollow cylindrical body taken through the points at which the brace is attached to the cylindrical body. The threads of the screw and its associated balls are drawn in another section plane, in order to improve illustration.

Figure 3 is a rear view of the foot.

The orthopedic foot illustrated in Figures 1-3 comprises a bar or foot blade 1, preferably made of carbon fibre material and intended to be attached to a bottom

part (not shown in the drawings) which functions as a walking sole and which is manufactured from some kind of rubber material, for example. The foot blade preferably comprises two parts, namely a main blade 2 and a toe blade 3. The length of the toe blade is preferably smaller than half the length of the main blade. The forward part of the main blade 2 and the rearward part of the toe blade 3 are curved upwards such as to form therebetween a cup-shaped part 4. A spring device 5, preferably made of an elastic material, such as rubber, is fitted in said cup-shaped part.

Arranged approximately centrally on the main blade 2 in the direction of its longitudinal axis is an upper foot-part which includes a hollow cylindrical body 6 which is attached to the foot-blade through the intermediary of rubber spacing blocks so as to obtain relative movement between the foot-blade and the upper foot-part. The upper foot-part is intended for attachment to a lower leg-part or to some other prosthesis, in accordance with a conventional method. The cylindrical body 6 is provided with two mutually opposed slots which extend in the direction of the longitudinal axis of said body. A ball nut 9 is mounted on journal bearings 10 in the lower part of the tubular body 6 so that said body can be rotated with the rotational axis lying along the cylinder axis of the cylindrical body. Extending in the ball nut 9 is a partially screw-threaded shaft which approximately midway of an upper non-threaded part is connected to a two-part brace 12 which extends from said shaft to the rear end of the foot blade 1, where it is connected to the foot blade through the intermediary of an elastic spacing block 13. This brace is comparable to the heel tendon of the human foot. A moveably mounted nylon piston 14 embraces

the shaft in the region of the upper attachment point of said brace to said shaft. One function of the piston is to form a support for an upper spring 15 and a lower spring 16, preferably made of an elastic, rubber material, and also to centre movement in the cylindrical body 6. The upper spring is also supported by a washer 17 which is located on the upper end of the shaft and which is locked by means of a nut 18. The bottom spring is also supported by a washer 19 which is mounted at the start of the screw-thread on the shaft, which is approximately midway along the shaft. The upper, non-threaded part of the shaft is bevelled in the longitudinal direction, therewith to prevent rotational movement. The threaded part of the shaft may move freely in the ball nut, as previously mentioned. This movement is activated by the prosthesis wearer but can be locked, however, by preventing rotation of the ball nut 9. This is effected by applying a braking force on the outer cylindrical surface 20 of the ball nut with the aid of a brake means. This brake means comprises a brake shoe or brake block 21 which lies against the cylindrical surface 20 when the brake is applied.

The brake means may alternatively have the form of a toothed ring placed around the cylindrical surface 20 and a pawl which engages said toothed ring when the brake is applied. This preferred variant includes a brake shoe 21 which, via an arm 22 which extends around half the circumference of the cylindrical body, is attached to a brake wire 23 which extends to a height along the leg appropriate to the wearer of the prosthesis. The casing 24 of the brake wire is attached to the outer surface of the cylindrical body 6 by means of an attachment device. The actual wire 23 itself is attached to the arm 22 via a spring 25.

The prosthetic foot functions in the following manner:
When the foot is attached to the lower leg of the user
and the ball nut is in its braking position, such that
5 the brake shoe 21 lies against the outer cylindrical
surface 20 of the ball nut, the brace 12, which extends
from the cylindrical body 6 to the foot blade 1, will
function similar to the heel tendon of a human foot.
The nylon piston to which the upper part of the brace
10 12 is attached moves up and down, in response to move-
ment of the centre of gravity between heel and toe
part. The two springs which transmit the force from the
brace to the shaft in the ball screw then mutually
coact with the rubber springs mounted in the foot blade
15 so that the foot is thrust forwards to some extent upon
completion of a walking step.

When the wearer intends to walk down a steep slope or
to change the angle of the foot for some other reason,
20 for instance to change shoes, etc., the wearer manoeuv-
res the brake wire so that the brake shoe will no
longer abut the ball nut. The shaft extending through
the ball nut can now be moved axially, thereby rotating
the ball nut. Adjustment to the desired angular posi-
25 tion can be effected by applying a requisite force on
the toe part or the heel part of the prosthetic foot.

The use of a ball nut and associated spindle has made
it possible within prosthesis technique to convert
30 linear motion to rotational motion with a limited
force. The realization of this with this particular
application is fundamental to the advent of this pros-
thesis.

The inventive prosthetic foot has many advantages. It stands flat and stable on the underlying support surface.

- 5 It constantly follows the direction in which the user walks, which eliminates wear on hip joints and on the spine.

- 10 The angle of the foot can be adjusted so as to enable the wearer to use shoes of differing heel heights and enables the angle of the foot to be readily adjusted to conform to the nature of the underlying support surface.

- 15 It will be understood that the present invention is not restricted to the aforescribed and illustrated embodiment and that modifications and changes can be made within the scope of the invention as defined in the following Claims.

CLAIMS

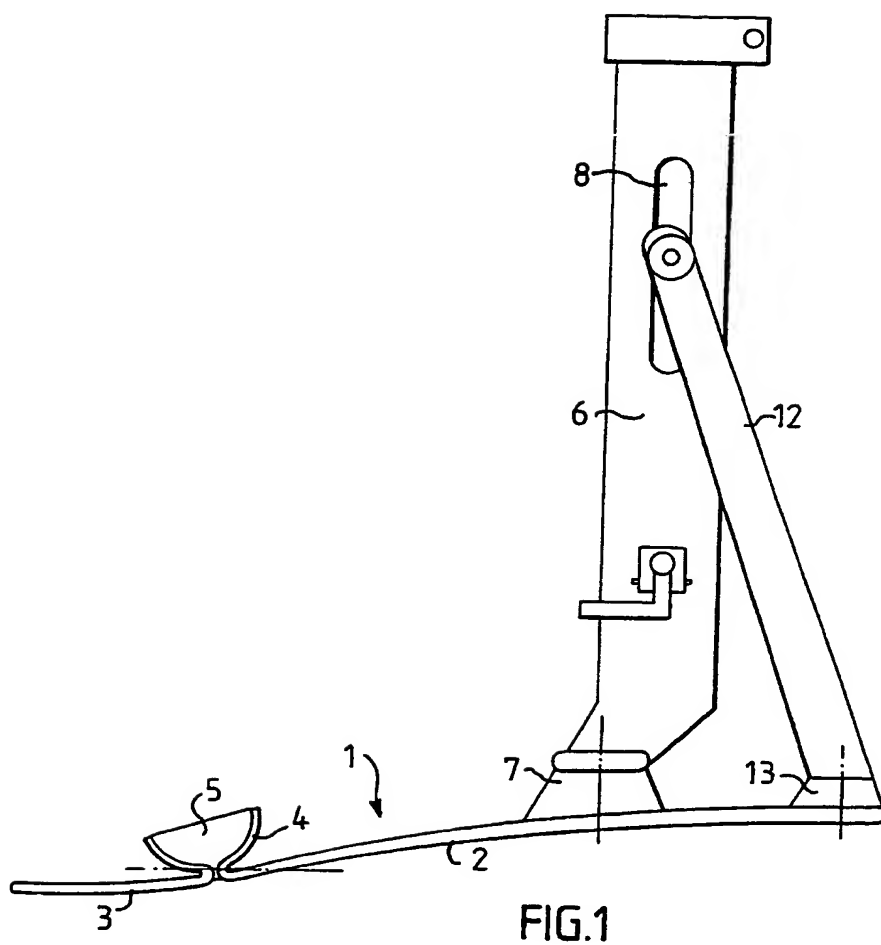
1. An artificial foot which includes a foot blade (1) and a hollow cylindrical body (6) which extends at an angle thereto and which is connected to said foot blade in a manner to permit relative movement therebetween, characterized in that a brace (12) is displaceably and adjustably mounted in an upper part of the cylindrical body (6); in that the lower end of the brace (12) is attached to the foot blade (1) in a manner such as to permit relative movement between the foot blade (1) and the brace (12), wherein the displaceability and adjustability of the brace (12) and therewith angular adjustment of the foot are achieved by virtue of the fact that the upper part of the brace (12) acts upon the shaft (11) in a ball screw having a rotatable ball nut (9) and by virtue of the fact that said brace can be locked against the inner surface of the cylindrical body (6).

2. A foot according to Claim 1, characterized in that the upper part of the brace (12) acts upon the shaft (11) in the ball nut (9) via a nylon piston (14) attached to said brace (12); and in that said piston activates the shaft (11) of the ball nut (9) via springs (15, 16) both in the locked and non-locked positions.

3. A foot according to Claim 2, characterized in that locking of the ball nut (9) is effected with the aid of a brake shoe (21) which is caused to abut the cylindrical surface (20) of the ball nut and therewith prevent rotation thereof.

4. A foot according to Claim 3, c h a r a c -
t e r i z e d in that the brake shoe (21) is mounted
on an arm (22) which influences abutment of the brake
5 shoe through the intermediary of a brake wire which can
be manipulated from the thigh of the wearer.

5. The use of a ball screw and ball nut as a construc-
tion element in the construction of a foot prosthesis
10 for the purpose of converting linear movement to ro-
tational movement of connected prosthesis components,
wherein the linear movement can be locked in any desir-
ed position by means of a brake device which prevents
rotation of the ball nut.



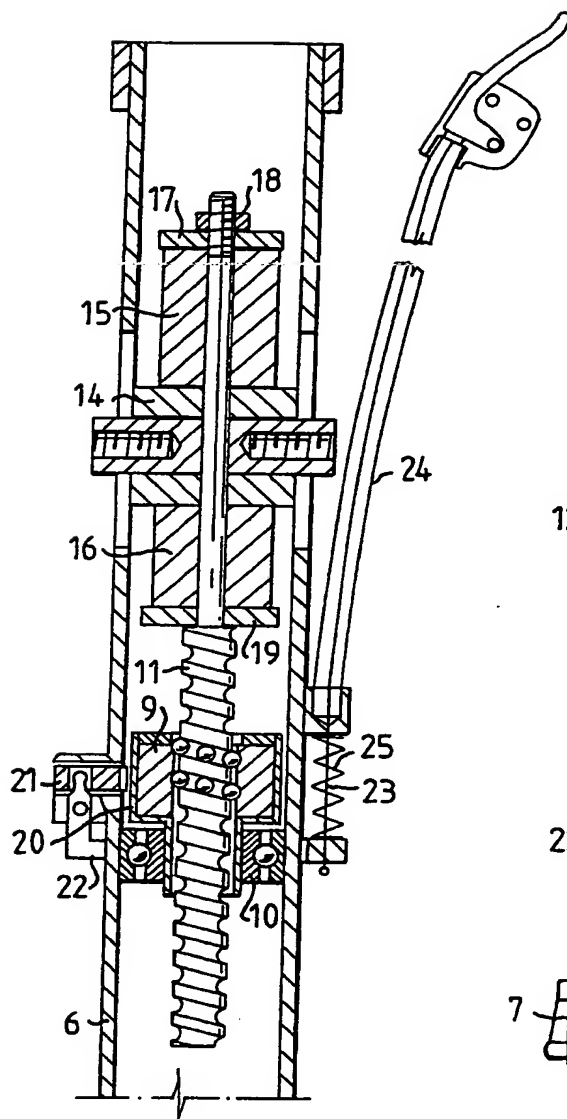


FIG. 2

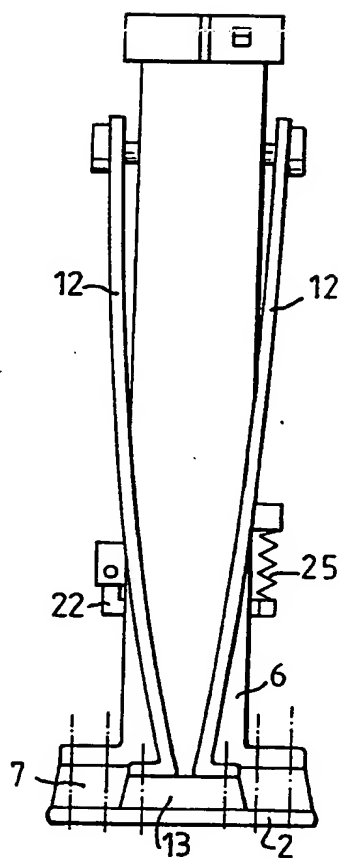


FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 91/00239

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: A 61 F 2/66		
II. FIELDS SEARCHED Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC5	A 61 F; F 16 H	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched ⁸ SE, DK, FI, NO classes as above		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	SE, B, 451177 (YNGVE LJUNGBLAD) 14 September 1987, see page 2, line 24 - line 35; figure 1 --	1
A	DE, C, 358818 (ADALBERT SCHIEVEKAMP) 16 September 1922, see page 2, line 61 - line 66; figure 4 --	1
A	US, A, 1049862 (J.W. HODGE & H.E. LA PLANT) 7 January 1913, see the whole document --	1
A	US, A, 1071230 (J.E. HANGER) 26 August 1913, see figure 9 --	1
<p>* Special categories of cited documents:¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
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25th June 1991		1991 -06- 27
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SWEDISH PATENT OFFICE Form PCT/ISA/210 (second sheet) (January 1985)		Leif Kanrsäter

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	<p>US, A, 4446580 (FURUYA ET AL) 8 May 1984, see figure 1</p> <p style="text-align: center;">-- -----</p>	1

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. PCT/SE 91/00239**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
SE-B- 451177	87-09-14	EP-A- 0280004 SE-A- 8504226	88-08-31 87-03-13
DE-C- 358818	22-09-16	NONE	
US-A- 1049862	13-01-07	NONE	
US-A- 1071230	13-08-26	NONE	
US-A- 4446580	84-05-08	NONE	